U. S. DEPARTMENT OF AGRICULTURE

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FARM STUDY OF THE COTTON PLANT

A FAIR KNOWLEDGE of the cotton plant is essential to the grower, not only from the standpoint of enabling him to care better for his crop and to utilize improved methods and varieties but also because of the fact that knowledge of the plants and their life functions tends to arouse a new and higher interest in farming. Such knowledge should enable the grower to see and appreciate the value of improved varieties, cultural methods, and systems of production.

By growing only one type of cotton regularly the farmer becomes more familiar with the habits of the plants and knows how they will behave under certain conditions. With a good understanding of the behavior of the plants, the grower is able to rogue out the off-type plants from fields that are to furnish planting seed, and not only has more interest and satisfaction in growing his crop properly but also receives a better return for his labor.

This bulletin describes the principal parts of the cotton plant and the growth habits and functions of each. The different parts are easily distinguishable and may be learned with little effort by considering each part as a separate unit and by thinking of the different units by name.

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FARM STUDY OF THE COTTON PLANT

By J. W. HUBBARD, *Senior Scientific Aide, Office of Cotton, Rubber, and Other Tropical Plants, Bureau of Plant Industry*

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INTRODUCTION

THE EFFORTS to avoid the depredations of the boll weevil have led to many valuable and interesting discoveries regarding the characters and habits of the cotton plant, as affecting its ability to produce good crops under weevil conditions. The selection of new varieties and the development of improved cultural methods are based on the knowledge of the habits of growth and development of the plant, and the principal features of the plant structure must be understood by the grower before a full utilization of such discoveries or improvements can be expected.

Without understanding the behavior of the plants, there is no practical means whereby one may judge the merits of a variety or method or make the tests or comparisons that may be necessary to determine differences of behavior under local conditions. Hence it appears that the farmer should have a fair knowledge of the principal parts of the cotton plant, together with their habits of growth and functions. Every farmer should at least know the type of cotton he is growing and be able to rogue out the off-type plants from fields that are to furnish planting seed. Farmers who are continually changing from one variety to another usually do not become familiar with the true characters of any of the varieties and are not able to detect the off-type or aberrant forms so readily as do farmers of 1-variety communities.

COMPARATIVE DIFFERENCES

Plants are like animals in being composed of many structural units which possess distinctive characters so that the different features can be observed and compared in detail, but most people have not learned to discriminate so closely among plant varieties as among breeds of animals. It is much easier to learn the distinctive characters of animals than of plants, because the visible parts of the animal's body

are directly comparable to those of the human body. With the plants there are no parts that are commonly recognized as comparable to parts of the human body, and consequently the plant more often is looked upon as a whole, without considering the particular features. In order to know and understand a plant, the structure and arrangement of its principal parts must be learned, for the foundation of knowledge of any object lies in an understanding of its component parts.

In studying the cotton plant two principal kinds of differences are encountered. The structural parts, such as branches, leaves, or fruit, may differ in themselves, or differences may be found in the number and arrangement of parts which otherwise are alike. The habits of branching include many features of practical importance to the farmer, both in relation to varieties and to cultural control.

TWO KINDS OF BRANCHES

The main stalk of the cotton plant consists of a series of nodes and internodes. The nodes are the joints where the leaves and branches are attached, and the internodes are the sections between the nodes. A leaf develops at each node, and at the base of each leaf are two small buds. The bud just above the axil of the leaf is called the axillary bud, and the one to the right or left is called the lateral or extra-axillary bud. As a rule the true axillary buds produce only vegetative branches, or "wood limbs," which function as secondary stalks. The extra-axillary buds are readily capable of producing either vegetative branches similar to those of the axillary buds, or the fruiting branches that bear the flowers and fruit. Usually only one of the buds develops at each node, the other remaining dormant, but in some varieties two branches are often produced from the same node. (Fig. 1.)

The leaves of the stalk are arranged in a spiral, and the right-hand or left-hand position of the fruiting branches is determined by the direction of the spiral and is regular for each plant. Some plants are right-handed and others left-handed with respect to the position of the branches.

Fruiting branches differ from the vegetative branches in that they are usually very much smaller, their positions are more nearly horizontal, and they produce a floral bud, or square, at each node. Also each fruiting-branch joint diverges from the direction of the preceding joint, forming a zigzag structure that often shows a strong contrast with the straight, round, stalklike vegetative limbs.

The positions on the main stalk of the two kinds of branches are also different and quite regular. As a rule, the vegetative branches occupy a definite zone near the base of the plant, while the fruiting branches begin farther up the stalk and occur regularly at each node. The number of nodes from the base of the main stalk to the lowest fruiting branch is not a constant character and varies considerably in different kinds of cotton and under different conditions of growth. In some cases the first fruiting branch may appear as low as the fifth or sixth node, while in others there may be twice as many nodes below the first fruiting branch. If vegetative branches do not develop, the lower nodes of the stalk usually remain vacant.

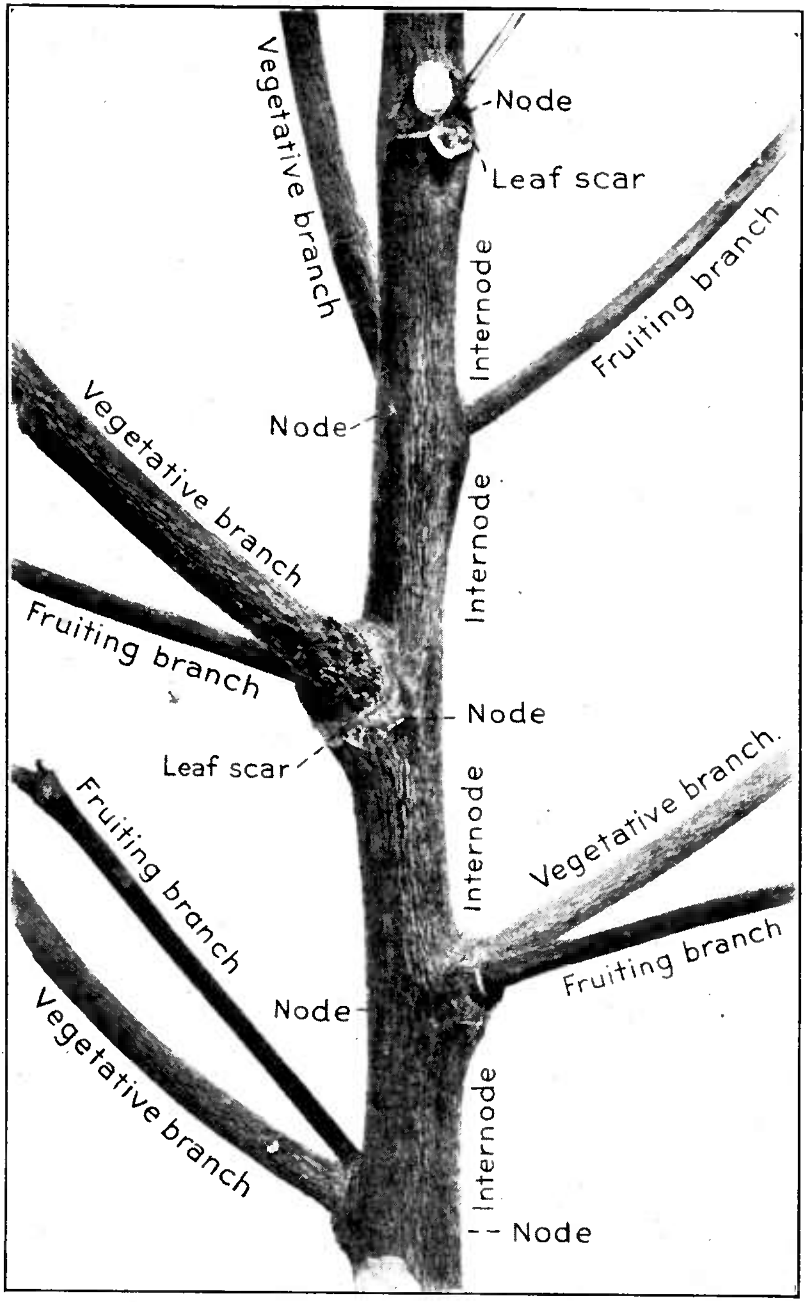

FIGURE 1.—Double branching, showing a section of a Lone Star cotton plant with a vegetative branch and a fruiting branch at four consecutive nodes. A leaf scar is shown at the upper node where the branch has been cut off; it shows the positions of the branches in relation to the leaves of the main stalk. The fruiting branch shown at the lower node was lifted above the vegetative branch to show its attachment at the node. (Nearly natural size)

The vegetative branches, developing from near the base of the stalk, usually have an upright position and often grow as tall as the main stalk, or even taller. Their function is practically the same as that of the main stalk, with an axillary and an extra-axillary bud produced at each node, from which the two kinds of branches are developed. (Fig. 2.) No flowers or fruit are produced directly on vegetative branches.

VEGETATIVE BRANCHES NOT DESIRABLE

Under boll-weevil conditions it is especially desirable to have the plants produce fruit rapidly and as early in the season as practicable. This is accomplished through closer spacing of the plants in the rows, since during the early flowering period a large number of these small plants produce more flowers and set more bolls than a smaller number of large plants occupying the same space in the rows. In some seasons it happens that a large proportion of the crop is set on the lower fruiting branches of the main stalk during the first two or three weeks after the plants begin to fruit, before any bolls can be set on the secondary fruiting branches produced by the vegetative branches, or "side stalks," as they sometimes are called. In such cases the yields have been found to depend more upon the number of plants per acre than upon the size of the plants. If the season is sufficiently long and no serious damages from insect pests are encountered, a smaller number of wide-spaced plants with large vegetative branches may yield as well as a larger number of small plants without vegetative branches. But where it is desired to produce the biggest crop in the shortest time, larger yields are obtained with more plants per acre. Plants with vegetative branches are not desirable and should be avoided by closer spacing.

The term "single stalk" is applied to plants that produce only fruiting branches. Plants that are spaced less than 1 foot apart in the row, or left in hills of two or more plants together, with the hills from 8 to 20 inches apart, usually do not produce any vegetative branches, or have only a slight growth of such branches, instead of the numerous "side stalks" of large rank-growing plants.

Closer spacing is being used more and more by the best growers, and most of the contests for larger yields have been won through this method. In many cases the seeds are planted at the rate of 20 to 25 pounds to the acre, and the stand is left unthinned. This method of leaving the cotton unthinned seems particularly adaptable to districts where seasons are short and the plants do not grow too rank.

DEVELOPMENT OF FRUITING BRANCHES

The manner of development of the fruiting branch is somewhat peculiar, in that the first part of the branch to become visible is the floral bud, or square, of the first node. As the branch develops the internode gradually lengthens, carrying the young bud and its leaf away from the stalk, as shown in Figure 3. The leaf at first is smaller than the square and grows rather slowly, usually unfolding from four to seven days after the square becomes visible. The floral bud of the next node appears in the axil of this leaf, usually at about the time the leaf unfolds, and later is carried away from this

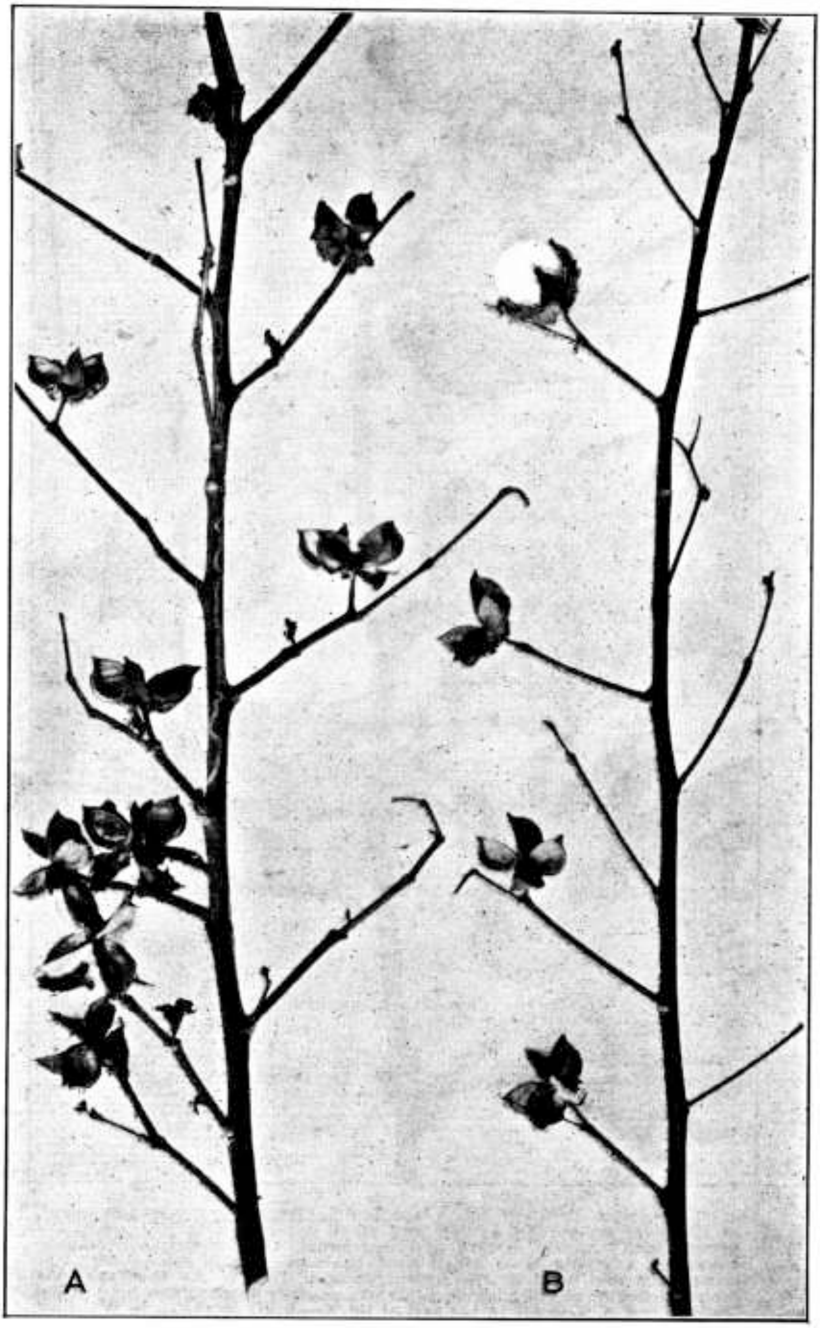

FIGURE 2.—Main stalk (A) and vegetative branch (B), both with fruiting branches showing section of a large vegetative branch in comparison with section of main stalk of the same plant

FIGURE 3.—Development of the cotton fruiting branch. It becomes visible at the stage represented by the very small square and folded leaf at the upper right. As the square and leaf grow, the supporting internode lengthens, carrying them away from the stalk. This square and leaf occupy the first joint of the fruiting branch. About the time that the first fruiting-branch leaf begins to unfold, another small square and folded leaf becomes perceptible in the axil of the first leaf, as shown in the third branch from the top. This second square and leaf occupy the second node of the fruiting branch and are carried away from the axil of the first leaf by a subsequent lengthening of the second internode. This process of development is repeated in successive joints of the fruiting branch, as shown at the left. Note the alternating positions of the floral bud at the nodes of the fruiting branch. (Nearly natural size)

position by the growth of the second internode. This procedure is followed throughout the development of the fruiting branch, the new floral buds usually appearing at intervals of from five to seven days. Thus it is seen that the floral buds or squares are formed as the branch develops, a bud at each node.

Under favorable warm-weather conditions the first fruiting branch usually appears from 20 to 30 days after planting, but more time is required during the early spring, as germination may be delayed and growth retarded by cool weather. Fruiting branches usually appear at successive nodes of the main stalk at 2-day to 3-day intervals, or about twice as fast as squares are formed on consecutive nodes of the fruiting branches. Thus a more rapid setting of fruit early in the season is made possible by having larger numbers of plants in the fields, as in the single-stalk system of close spacing, than with smaller numbers of larger wide-spaced plants that produce a part of their crop on secondary branches from the vegetative limbs.

DEVELOPMENT OF SQUARES AND BOLLS

The period of development from the appearance of a square or floral bud until the bloom opens has been studied in several varieties of upland cotton and found to be practically the same, the average period ranging between 25 to 30 days. Likewise, the period from flower to open boll has been determined and found to be nearly the same among the upland varieties. The time required is usually between 35 to 45 days, but it depends to a great extent on seasonal conditions. Late-season bolls often require from 10 to 20 days longer to open than bolls of the same plant produced earlier in the season. Thus the periods of square development and of the growth and opening of the bolls apparently are not of first-rank importance as factors of earliness. Other factors now recognized are rapid early growth, development of fruiting branches from lower nodes of the main stalk, and retention of the squares and bolls produced early in the season.

DANGER OF MISJUDGING EARLINESS OF VARIETIES

Some varieties of cotton have more determinate habits of growth than others; that is, they stop growing more promptly after a few bolls have been set, especially if dry weather is encountered. Such varieties may open all their bolls before frost and give an impression of being very early. Other varieties may set fruit as promptly at the beginning of the season, but continue to grow and produce bolls for a longer period. Some of the late-season bolls of a continued-fruiting variety may not open until frost, so that the variety appears to be late, even though a larger crop of bolls may have matured than in the type that seemed to be early. Such differences of fruiting habits have been shown in careful side-by-side comparisons of different varieties. Varieties should not be considered late merely because they continue to grow and produce a top crop which may be caught by the frost, but should be judged on the amount of seed cotton matured before frost. Such determinations should be made from the actual picking weights of carefully conducted side-by-side comparisons, as the appearance in the field is often deceiving.

THE INVOLUCRE

The floral bud of the cotton plant has an outer envelope, termed in botany an involucre, which is formed of three small leaves, or bracts, set close together in a triangle with the bud in the center. The involucre may be considered as replacing the calyx, which in the cotton plant is very small and covers the bud only in the early stages. No doubt the primary function of the involucre is to cover the young buds, though such protection apparently is not necessary under the usual cultural conditions and may even have disadvantages. The involucre often is a hiding place and point of attack for boll weevils, bollworms, mildews, anthracnose, and other pests and diseases that destroy many of the buds and bolls. Another disadvantage of the involucre is that much of the "trash" which lowers the commercial grade of the cotton consists of broken bract material. In varieties with large involucres more of the bract material is picked with the cotton and becomes entangled with the fiber during ginning.

The breeding of cotton varieties with smaller involucres is worth considering, not only to make poisoning easier and reduce the losses caused by weevils and other insect pests but also at the same time to improve the grade of fiber by reducing the amount of trash. The Acala cotton has smaller bracts than most varieties of the Texas big-boll series, and strains with still smaller involucres probably could be established through careful breeding work. Tropical types of cotton have been found with extremely small bracts which give very little shelter to insect pests and diseases.

HAIRY SURFACES OF COTTON PLANTS

The cotton plant has a covering of hairs on the surfaces of the leaves, bracts, and young stems. The extent of hairiness varies greatly in different species. In some species the hairs are very dense, giving the plants a grayish color and a soft surface texture similar to velvet. Other species have the hairs so sparse as not to be noticeable without close examination. Most of the hairs are not simple but are united in clusters and project in all directions from the point of attachment, forming stellate or star-shaped groups. These clusters of hairs make it difficult to separate completely the trash from the cotton fiber. Cleaning devices at the gins would readily remove even the small bits of dead leaves and bracts if they were smooth or had only simple hairs, but some of the fibers become so entangled in the stellate hairs that it is practically impossible to separate all of the trash particles from the fiber at the gin. The tangled fibers and the small bits of trash are either combed out as waste in the spinning operations or remain to cause blemishes in the finished mill product.

At present no type of cotton is known that is entirely devoid of hairs, though many variations exist in the nature and extent of hairiness. In some species most of the hairs are shed before the leaves have reached full size, while in others the hairs are very persistent, even on the old stems. A new species of cotton with simple hairs has been discovered recently in South America but is not adapted for cultivation in the United States.

The reduction or suppression of the stellate hairs is a character to be considered in breeding. The development of varieties with only simple hairs might be possible if the desirability of this character is recognized in the work of selection.

FLUCTUATING CHARACTERS OF LEAVES AND BOLLS

Some of the characters of cotton plants are regular and constant, while other characters are much more variable. Two examples of such differences which are present in all varieties of upland cotton and on practically every individual plant are the differences in the lobing of the leaves and in the number of locks in the bolls. It is a common mistake among those unfamiliar with the cotton plant to suppose that the presence of variously lobed leaves or of bolls with different numbers of locks, as 3-lock, 4-lock, or 5-lock bolls, is an indication of a mixed stock. These irregularities are normal and have no bearing upon the purity of the variety, though many other characters of the leaves and bolls are important in recognizing differences among the plants.

Apart from the number of locks, the shape of the boll is one of the most important characters to consider in selection, since it is usually associated with other distinctive characters. (Fig. 4.) Uniformity of fiber, which is one of the most important factors in determining the value of a variety of cotton, is evidenced by uniformity of boll shape, and the length of fiber also may be judged to a considerable extent from the shape of the boll. A round boll usually represents rather short fiber, and a long gradually pointed boll usually represents rather long fiber. As a general rule, the longer the boll the longer the fiber.

The storm-proof character also appears to be associated with the shape of the boll in the same manner as the length of the fiber. Most of the upland varieties having short, round bolls are characterized by short fiber that strings out of the bolls soon after opening. This fluffing and stringing out of the lint gives an impression of a larger yield in comparison with the storm-proof varieties, in which the lint remains in the boll in a compact mass. Storm proofness may be considered as an indication of good length and quality of fiber as well as protection from storm damage. Such relations might well be expected, since the length and quality of the fiber and the structure of the carpel are important factors in determining storm proofness.

Another boll character that usually is associated with the short, round forms is the "split-nose" or "harelip" deformity, represented by distinct grooves or splits between the carpels at the tip of the boll. These grooves, or open sutures, render the bolls much more susceptible to diseases and should be carefully avoided when making selections. (Fig. 5.)

SEED AND LINT CHARACTERS

The seeds of most varieties of cotton produce two distinct kinds of hairs—long hairs, represented by the lint fibers, and much shorter, finer hairs, commonly called "fuzz." In some varieties the fuzz fibers may be uniformly white like the lint, but in most cases the fuzz has a brown or greenish cast. The color and density of the

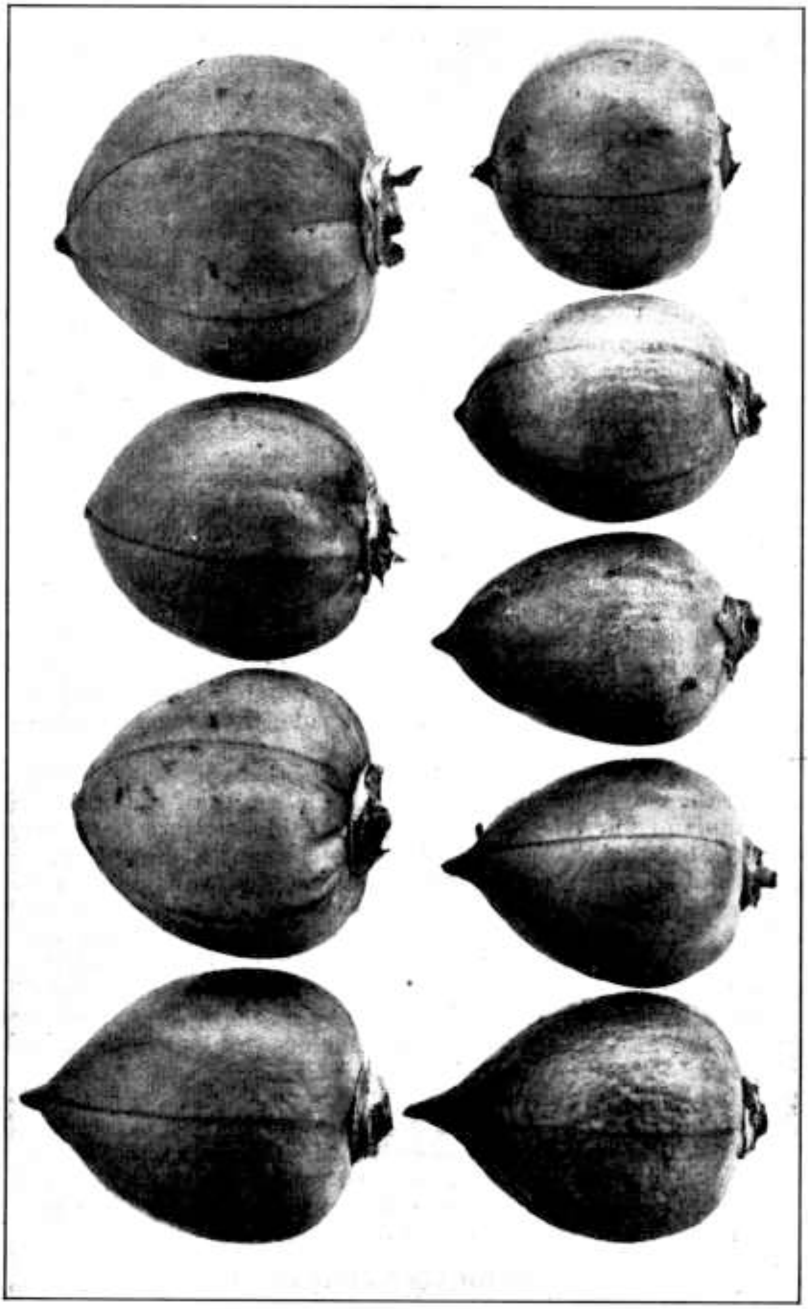

FIGURE 4.—Variations in the shape of mature, unopened bolls. Variations in the size of the bolls may be due to conditions and may have little bearing on the purity of the variety, but frequent variations in the shape of the bolls are a definite indication of mixing or neglect of selection. It is necessary to adhere strictly to a single-boll type in order to establish and maintain a uniform length and quality of staple. (Nearly natural size)

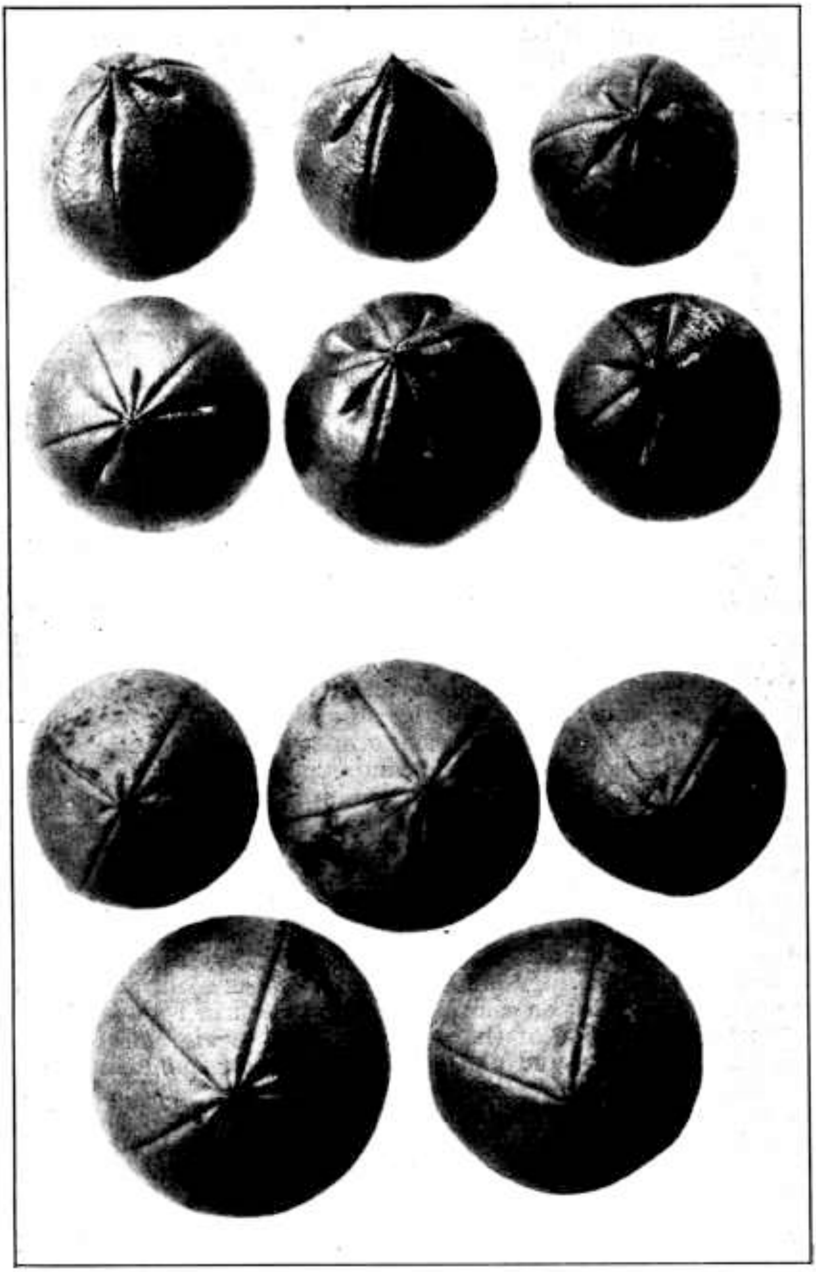

FIGURE 5.—"Split-nose" or "harelip" deformity, showing the grooves or folds between the locks. These are recognized as an inherited tendency, comparable to the harelip defect in animals. They should always be avoided in selection and breeding. (Nearly natural size)

fuzz varies greatly among different varieties, and slight variations of color are usually to be found in the most uniform seed stocks. Conditions of growth also may affect the fuzz characters, so that small variations in the color or density of the fuzz are not to be taken as proving that a seed stock is not pure. On the other hand, there seems to be a general relation between density of fuzz and abundance of lint. Types with little or no fuzz are usually found to have smaller percentages of lint, and extreme variations have been found with neither fuzz nor lint.

The length of the fuzz is also quite variable, and the amount of fuzz taken off in ginning is a factor in the turnout or percentage of lint obtained at the gin. Varieties with long fuzz can be made to give a higher gin turnout than those with short fuzz, but the extra lint percentage obtained by close ginning consists almost entirely of linters. The term "linters" is usually applied to the fuzz and other short fibers which normally are removed by reginning at the oil mill to make it easier to extract the oil. Running more linters into the bales by close ginning adds to the waste that must be separated from the fiber in the spinning mill. The higher turnout at the gin may give the farmer no real advantage, as the commercial grade of the cotton may be reduced. Where premium cotton is being grown, the addition of 2 per cent more linters to the cotton to give a high turnout may lose the farmer a premium of several cents a pound, as buyers often refuse to pay full premiums on wasty cotton.

COTTON COMBING

To determine the length and uniformity of lint in a bale of ginned cotton by the commercial practice of cotton classing is a difficult matter, and the operations, when properly done, require skill obtained only through long practice and experience. The exact length and uniformity of fiber lengths in a sample now may be determined readily and easily by laboratory technologists through recent developments, but such methods, equipment, and conditions are not available to the usual cotton farmer. He may, however, determine these elements of quality by a simple and more practical process, namely, the combing of the lint while attached to the seed. This method consists in parting the lint along the raphe, or seam, marked by a black ridge along the back of the seed, and combing the fibers out straight on each side, as illustrated in Figure 6. When the fibers on one side of the seed have been straightened they are pulled from the seed and placed on a dark background for measuring. Since the lint on each side of a normal seed is alike, only one side need be combed for measuring, unless very careful comparisons are to be made or material is being prepared for exhibits. A thin pocket comb with smooth teeth is suitable for this work, and a small piece of black woolen or velvet cloth glued on a smooth board makes a very good background on which to measure or make comparisons. To determine the length and uniformity of lint in a variety, strain, or progeny, several combings should be made. A good plan is to comb the lint of one seed from each of 25 or more consecutive plants.

Figure 6 illustrates the methods usually employed in combing the lint on the seed to determine the length and uniformity of fiber

FIGURE 6.—Cottonseed with the staple combed out. (Nearly natural size)

when special care is not being taken. At the top is shown a lock of cotton stretched almost to the point of separating the lint of the individual seeds and with the lint parting along a dark line at the back of each seed. This is the first step in combing. Then one of the seeds that shows the dividing line distinctly should be removed with the lint attached and the division of the fibers completed, as shown in the row second from the top. To comb, grasp the seed and the base of the fibers firmly between the second joint of the index finger and the ball of the thumb, so that the lint of one side of the seed protrudes in front of the partly closed hand. Then insert the teeth of the comb into the portion of the lint that is in front of the finger and comb gently away from the seed to straighten the fibers. If the fibers are tangled it will be necessary to comb more carefully and to change the grip from the seed to the fibers that are partly combed in order to hold them on the seed while the tangles are being removed. If the fibers are badly tangled and broken or become detached from the seed, the combing is spoiled and another must be made. The combing operation is continued until the fibers are straightened, as shown in the third row from the top.

If only the length and uniformity of the lint are to be judged, the combed fiber may be pulled from the seed and placed on a board for measuring, as shown in the fourth row. Care should be taken to grasp the lint firmly when pulling it from the seed to keep it even for measuring. If the combing is to be used in an exhibit or for making accurate comparisons the lint is combed on both sides of the seed. When fibers on both sides of the seed have been straightened, the combing should appear as shown in the bottom rows. Examples of more careful preparations of combings are shown in Figure 7.

LINT PERCENTAGE

The percentage of lint, or gin turnout, is the relation between the weight of fiber and the weight of seed. Farmers are often mistaken in attaching too great importance to the percentage of lint without considering other features. The same amount of fiber ginned from a given number of large seeds will represent a much smaller lint percentage than if ginned from the same number of small seeds. In selection for larger seeds the weight is increased more rapidly than the surface or lint-bearing area, so that the percentage of lint may be reduced even though more lint per acre is obtained. A high turnout is not a proof of high yield.

The number of seeds per boll may be an important factor in the breeding of high-yielding varieties. With the same quantity of seed material divided into a larger number of seeds, the lint-bearing surface is increased. Making the seeds smaller increases the lint percentage and would also increase the production of lint per boll if more seeds were formed. Merely by reducing the size of the seeds, the lint percentage would be increased, though the actual amount of lint would be less; but by reducing the size and increasing the number of seeds, so that the same quantity of seed material is maintained, the lint production would be higher.

An objection to small seeds is that the seedlings may be smaller and weaker so that they may fail to emerge from crusted soil or may suffer more from unfavorable conditions than the larger and

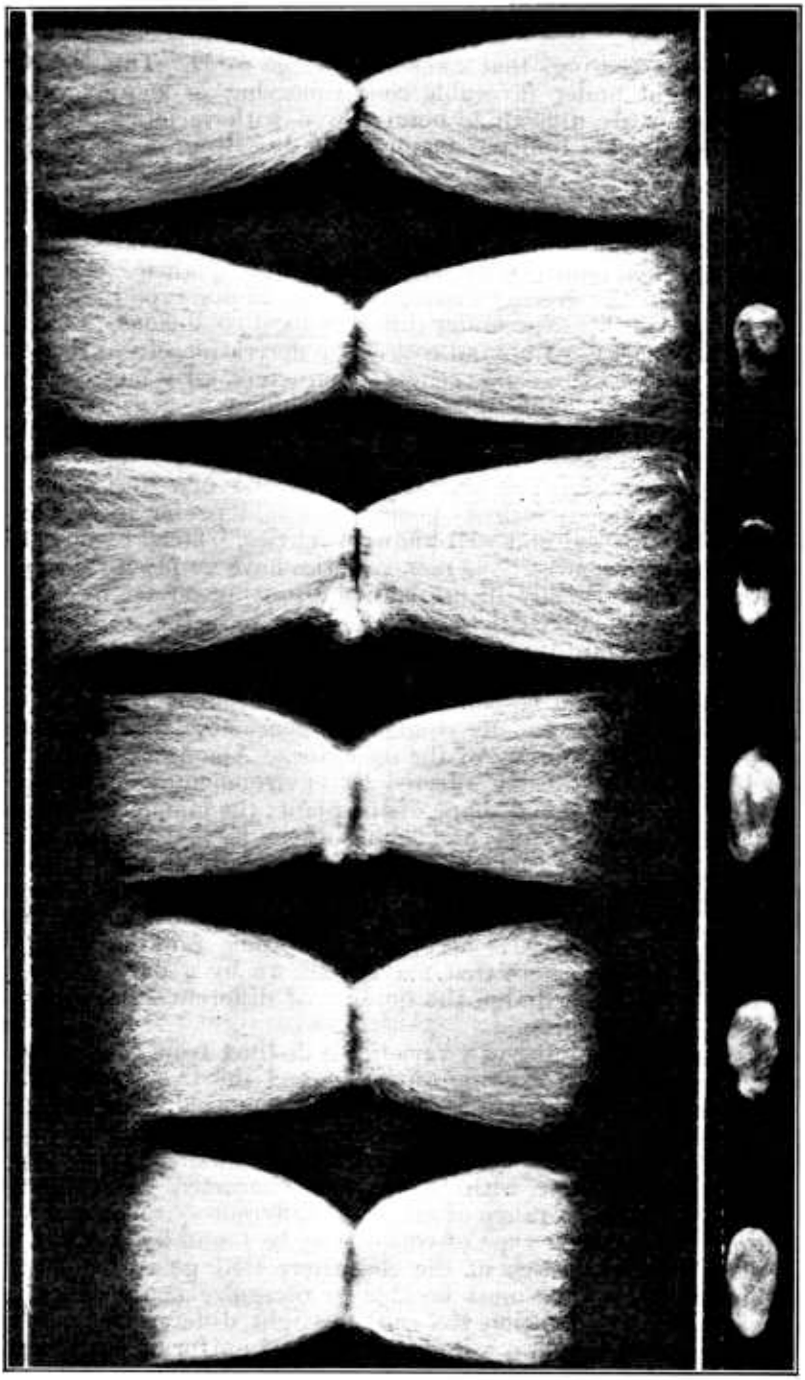

FIGURE 7.—Combed lint and seeds of six superior varieties of cotton. In order from top to bottom these varieties are Seabrook (sea island) Pima (Egyptian), Meade, Durango, Acala, and Lone Star. All these varieties except sea island have been developed by the United States Department of Agriculture and are extensively grown in different parts of the American Cotton Belt. (Natural size)

more vigorous seedlings that come from large seeds. This objection would be slight under favorable conditions, but in many localities uniform stands are difficult to obtain, even with varieties that have large seeds. Thus a limiting factor is the breeding of small-seeded varieties.

SUMMARY OF BREEDING PROBLEMS

Success in the breeding of varieties or strains of cotton and in keeping up their uniformity and other high qualities is largely dependent upon the breeder's ability to hold to one type in selection and to recognize this type under different local conditions. Many of the popular varieties of upland cotton are derivations from the same stocks and possess the same general characters. In fact, some of the varieties are so closely related and so similar in general appearance that they are very difficult to distinguish, and even their "originators" may be unable to point out any definite characters to separate them from their parental stocks. If the breeding problems were well understood, farmers generally would prefer to buy good stocks of seed of tried and well-known varieties, instead of novelties. Many of the highly advertised new varieties have no practical advantages over others already in use, and the putting out of many new kinds may be considered detrimental to the industry, representing an enormous expenditure to little purpose.

One of the principal difficulties encountered in cotton breeding is that the cotton plant responds readily to different conditions of growth and may show many changes of characters that have little or no bearing on the purity of the seed stock. Among the important characters that are greatly affected by environmental and cultural conditions are the size and shape of the plant; the manner of branching; the size, shape, texture, and lobing of the leaves; the size of the bolls; and the number of locks in the bolls. Many slight variations of these characters may be recognized in any field of cotton, progeny block, progeny row, or even on the individual plants of the most uniform stocks. Thus it is necessary to become familiar with the entire range of characters that may be shown by a particular type of cotton, in order to judge the quality of different stocks of seed and to facilitate roguing.

The work of developing new varieties is distinct from that of maintaining uniformity in existing varieties, and the two undertakings are far more different than is generally recognized. To maintain uniformity is the more difficult task, because it is necessary to adhere strictly to one particular type. In order to do this it is necessary to be thoroughly familiar with the various characters of the cotton plant and to know the range of effects of different seasonal and local conditions. A superior type of cotton may be found by one who has only a limited knowledge of the characters that go to make up a superior plant, but one must be able to recognize many characters and take into consideration the endless slight differences that may occur in order to maintain a high standard of uniformity in a select stock.

More definite knowledge of the cotton plant should enable breeders to find new characters or to establish and maintain new combinations of characters that would serve as improvements over the present

varieties. Such changes may best be accomplished through the use and gradual improvement of a few superior varieties and by organized breeding efforts of entire communities or districts, instead of depending upon the desultory efforts of scattered individual seed growers. The same varieties are being grown successfully over wide areas of the Cotton Belt, and only one variety is needed in each locality.

A reduction in the number of varieties not only would lessen the work of maintaining and further improving the seed stocks but would add greatly to the value of the product and to the returns received by the growers. Such advantages have been shown by growing the Acala variety in California, where provisions have been made to exclude all other varieties. This exclusion of other varieties prevents hybridization and the subsequent deterioration of the stocks of pure seed. Such protection against mongrel breeds must be recognized as an essential requirement in cotton production, to establish and maintain a creditable cotton-growing industry.

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